Beam shape at DØ

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Beam width measurement at DØ

The model we are using is very simple:

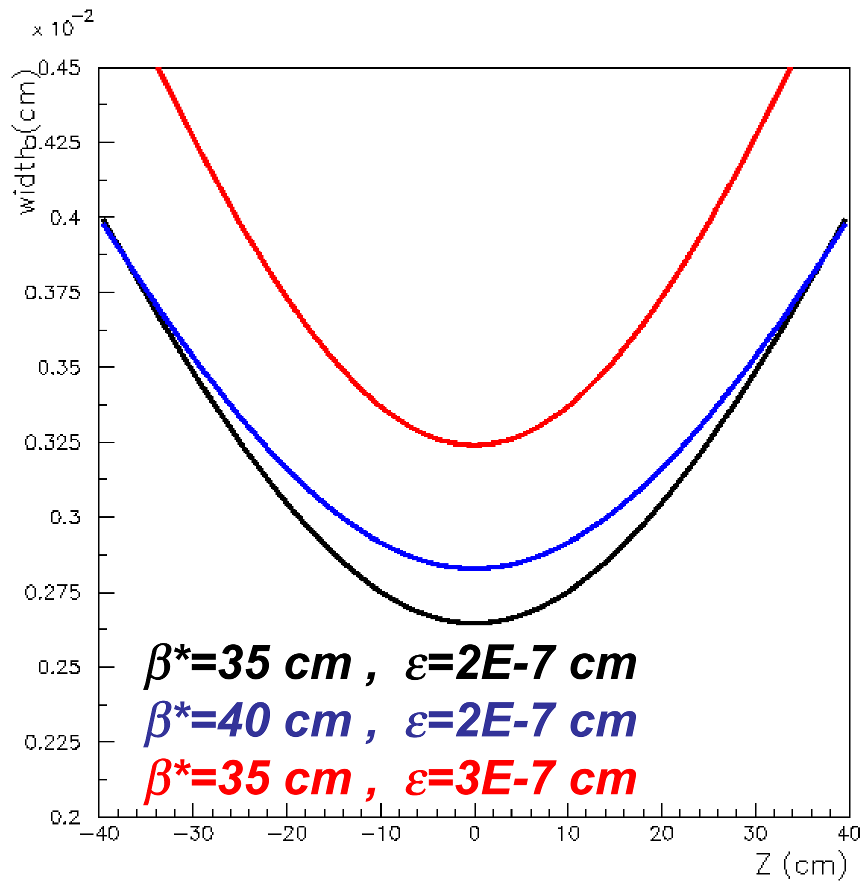
Two beams with no X-Y coupling, same "optic" for p and pbar.

The interaction region is a drift in the Tevatron, one expects.

$$\sigma^2 = \varepsilon_{eff}\left[\beta^* + \frac{(z - z_0)^2}{\beta^*}\right]$$

$$\varepsilon_{eff} = \frac{\varepsilon_p \varepsilon_{pbar}}{\varepsilon_p + \varepsilon_{pbar}}$$

In the beams division they expect ***β*=35 cm*.**



measurement of the shape of the luminous region

vertex method

$$\sigma_{obs}^2 = \sigma_{beam}^2 + k \times \sigma_{vertex}^2$$

Uses:

•coordinates of the reconstructed vertexes

•estimated errors on this vertexes

Assumes:

•unbiased reconstructed vertex position

•error estimation proportional to the real error

pair of tracks method

$$d_i = y\cos(\varphi_i) - x\sin(\varphi_i)$$

$$\langle d_1 d_2 \rangle = \sigma_F^2 \cos(\varphi_1 - \varphi_2)$$

Uses:

•track parameters

Assumes:

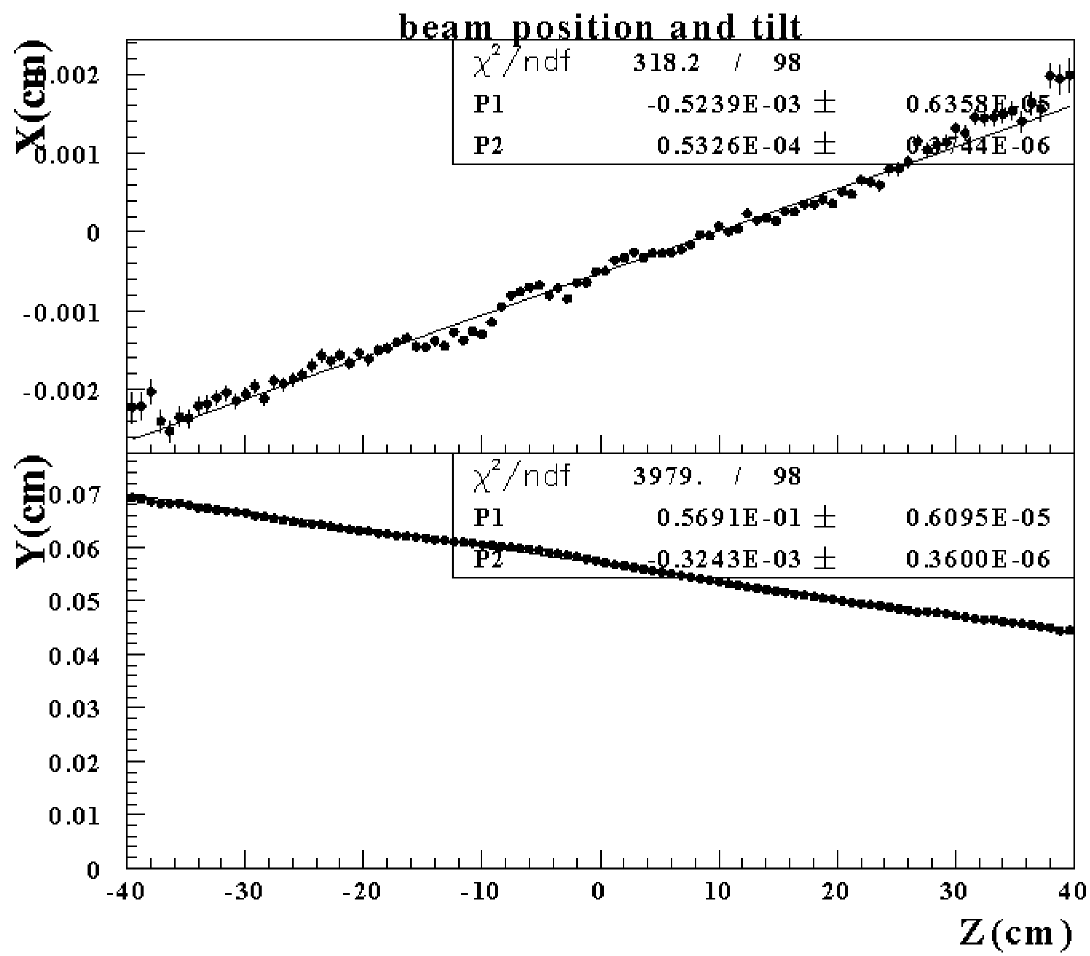
•unbiased track parameters

•uncorrelated errors in the track parameters

Here I assume circular beam, but in our calculation we do not make this assumption (formula a bit more complicated).

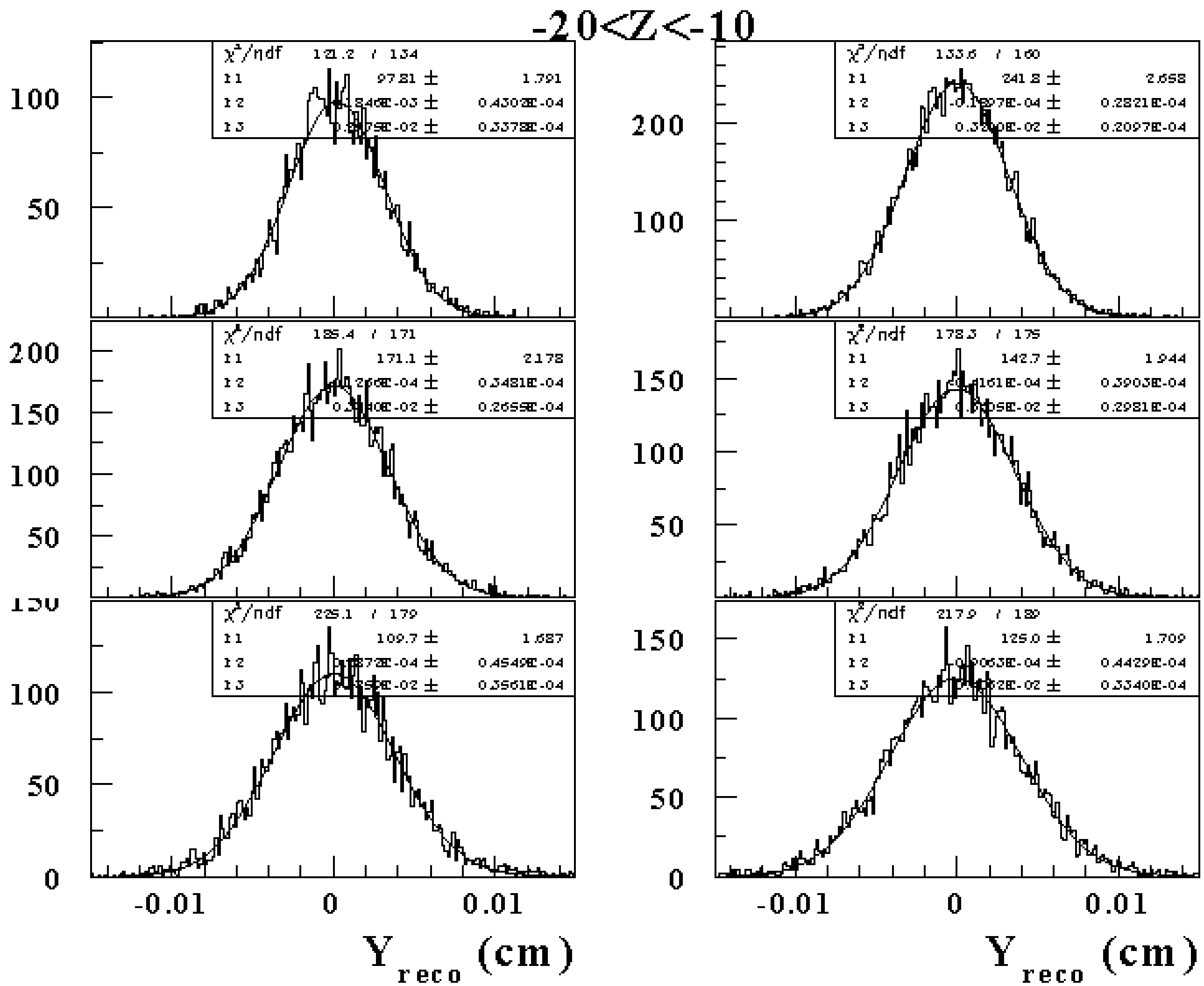
Vertex method. Step 1

Take one full run, and determine the beam tilt and position for X and Y independently.

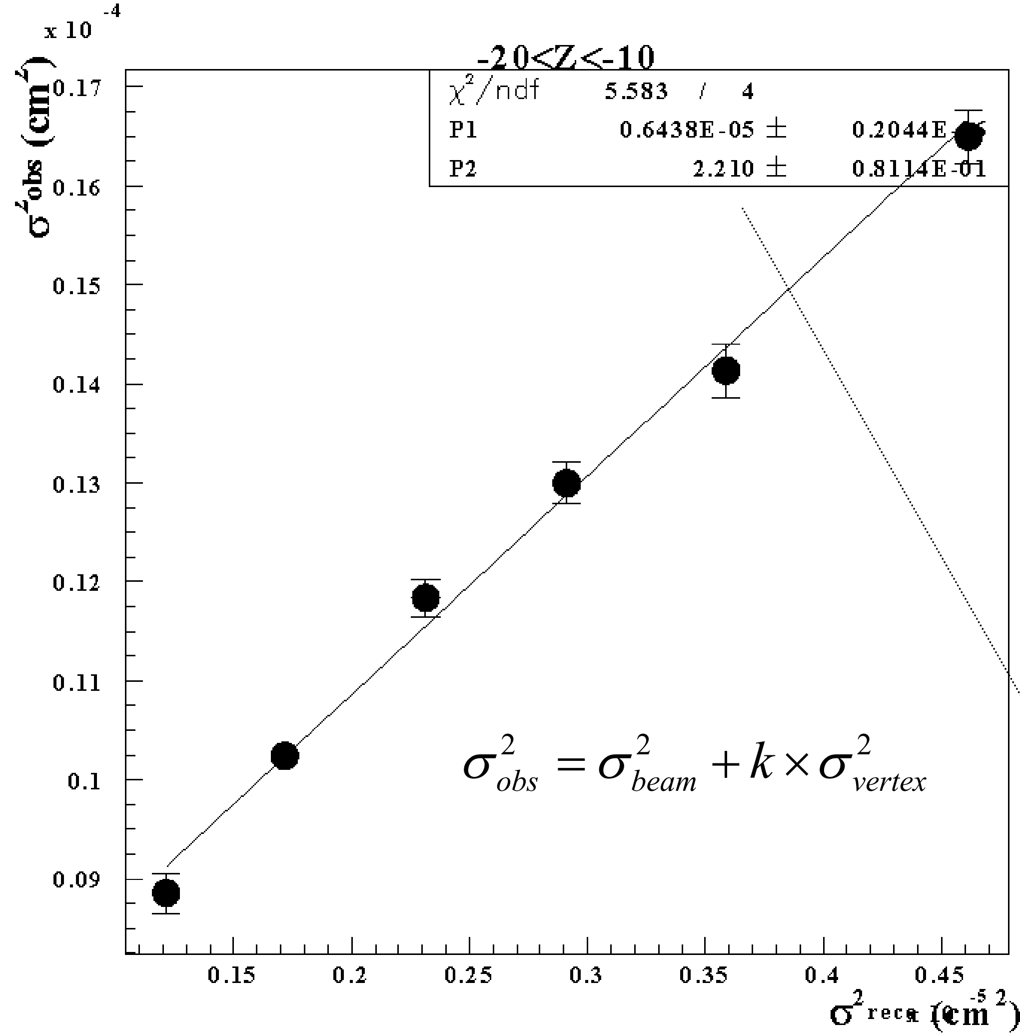


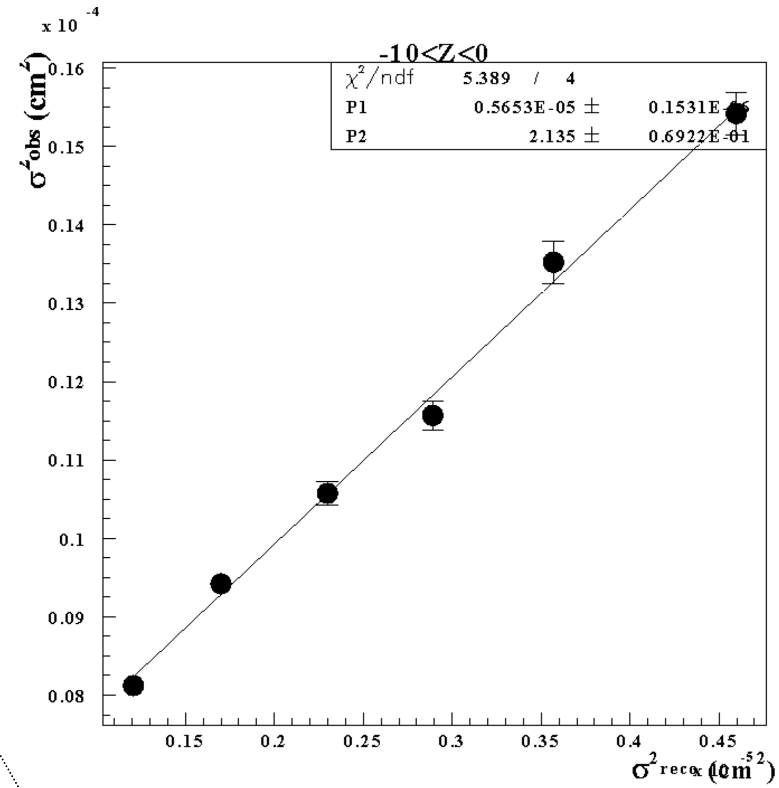
Vertex method. Step 2

For each Z beam (10 cm), separate the data in σ_{reco} bins and fit the width of the observed discribution.



Vertex method. Step 3

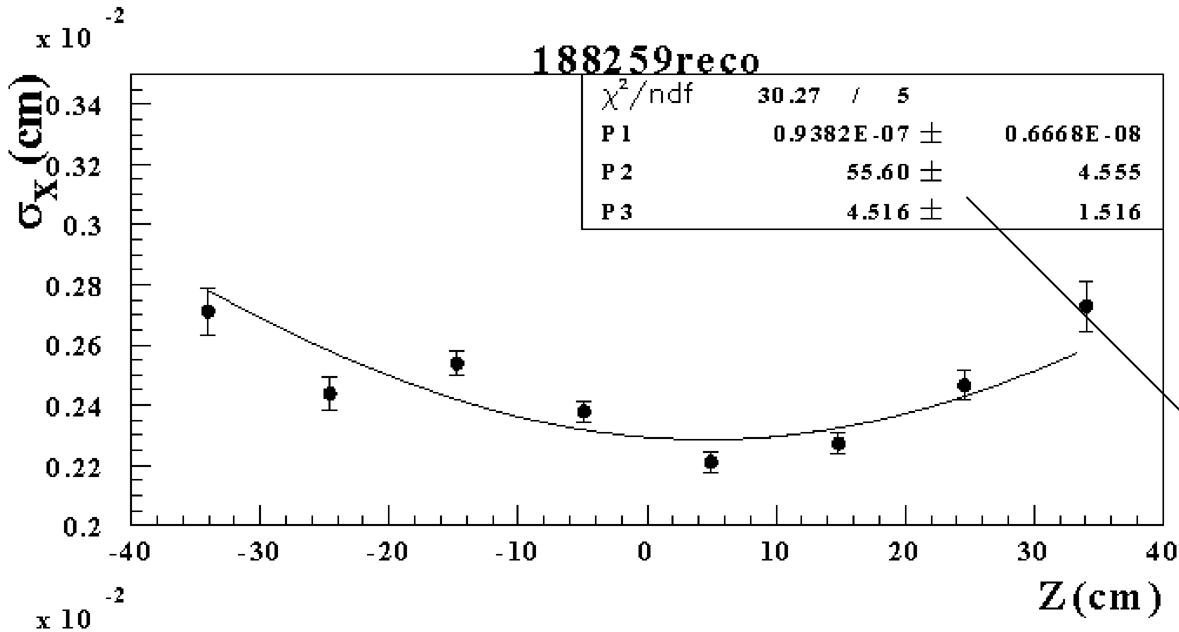


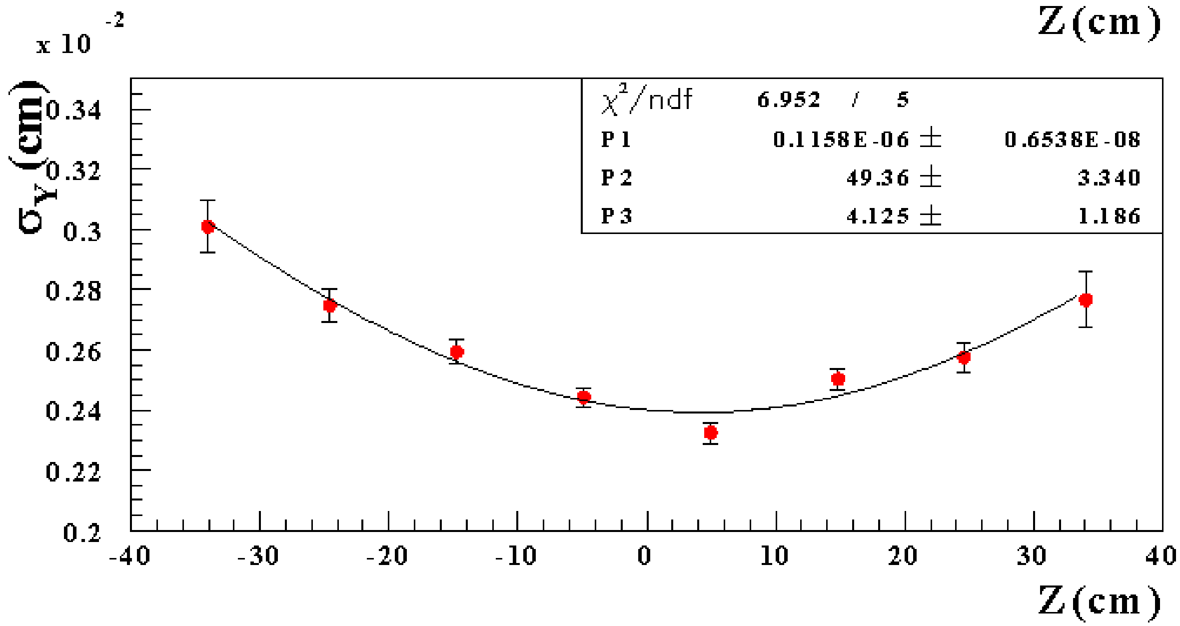


k=1 if you have a good estimator for the error in the vertex position.

fit the linear equations and determine k and σ_{beam}.

Vertex method. Step 4



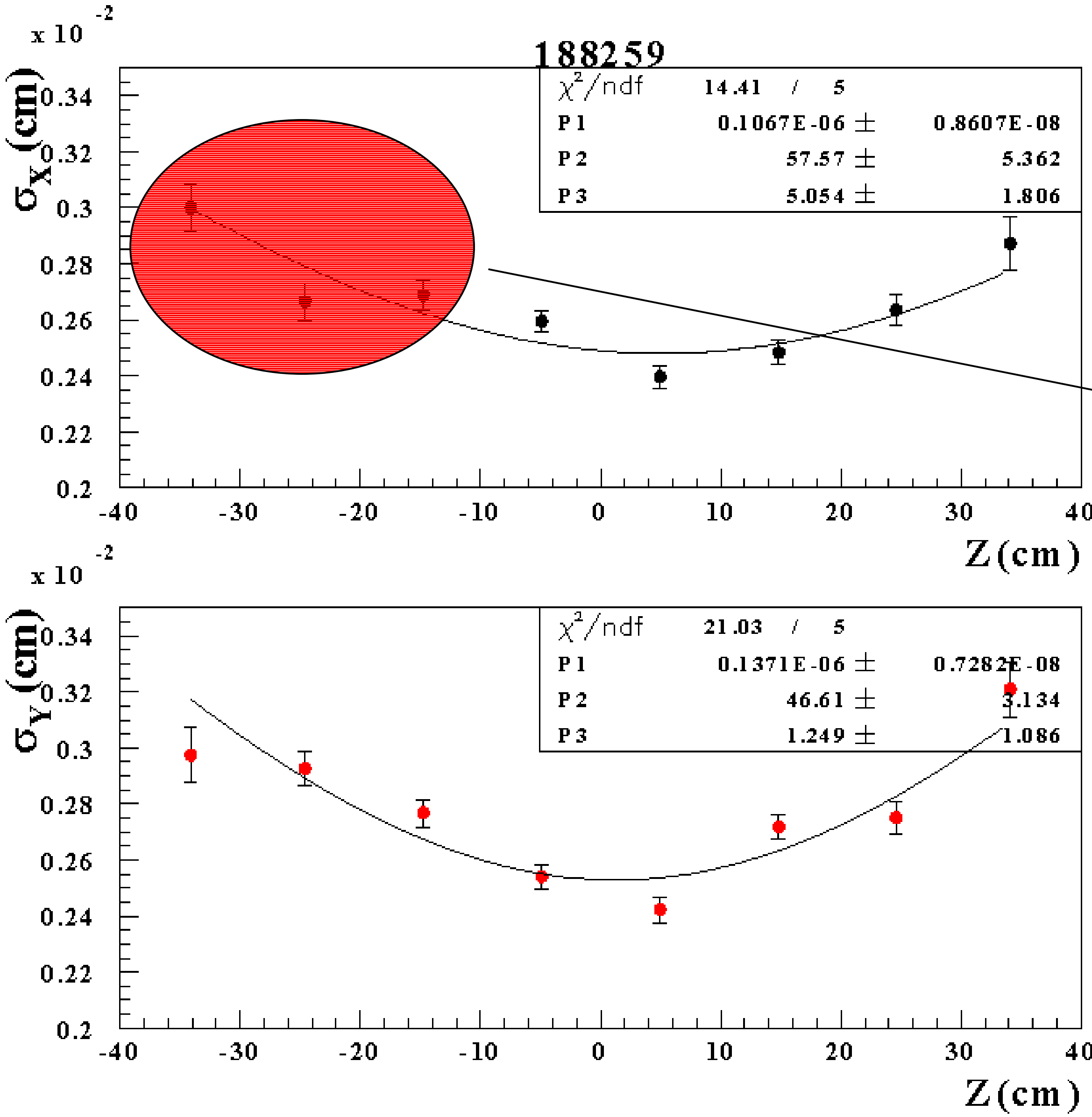


Fit β*

$$\sigma^2 = \varepsilon_{eff}\left[\beta^* + \frac{(z-z_0)^2}{\beta^*}\right]$$

Tevatron department will say this β* is impossible.

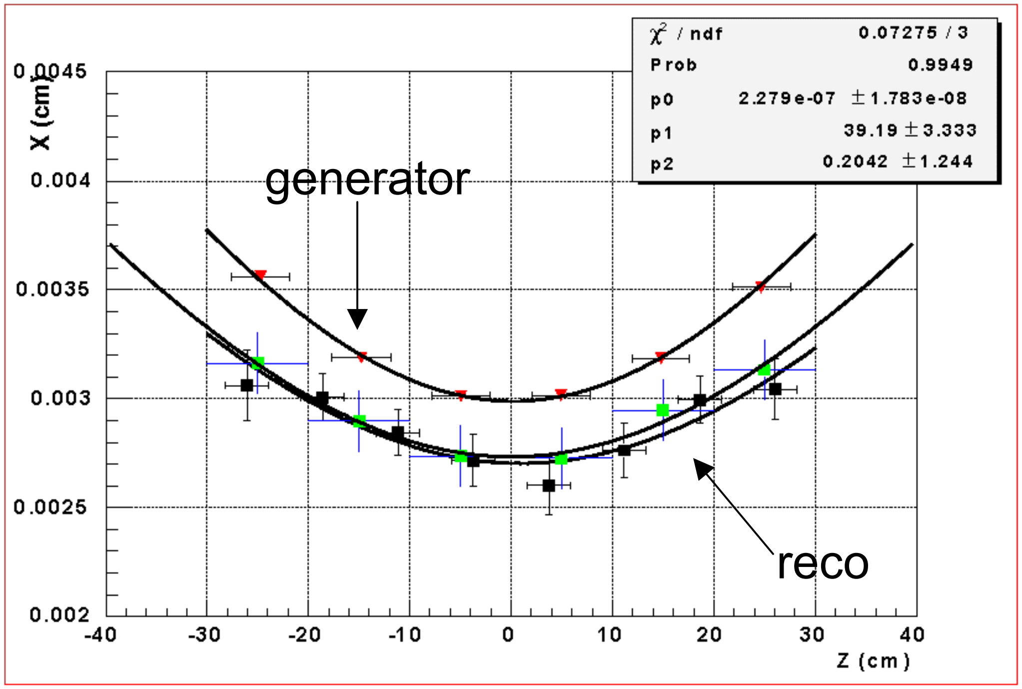
Vertex Method. Step 4 (again)

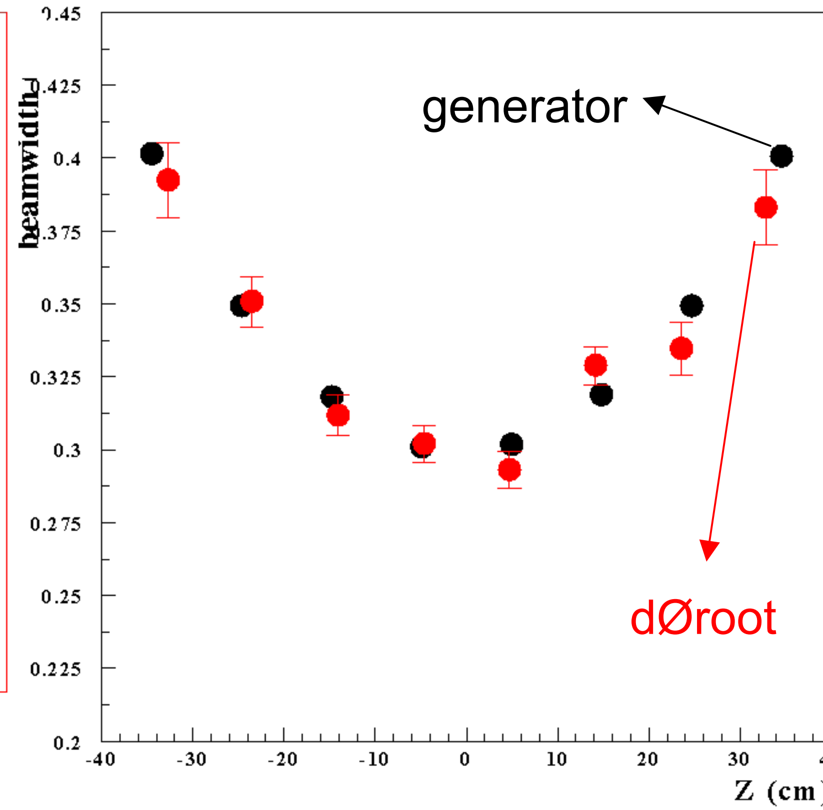


Revertexing (d0root) solves a 10% bias in the vertex, but the change seen in β^0 is not big.

It looks like this after the shutdown.

We test in MC





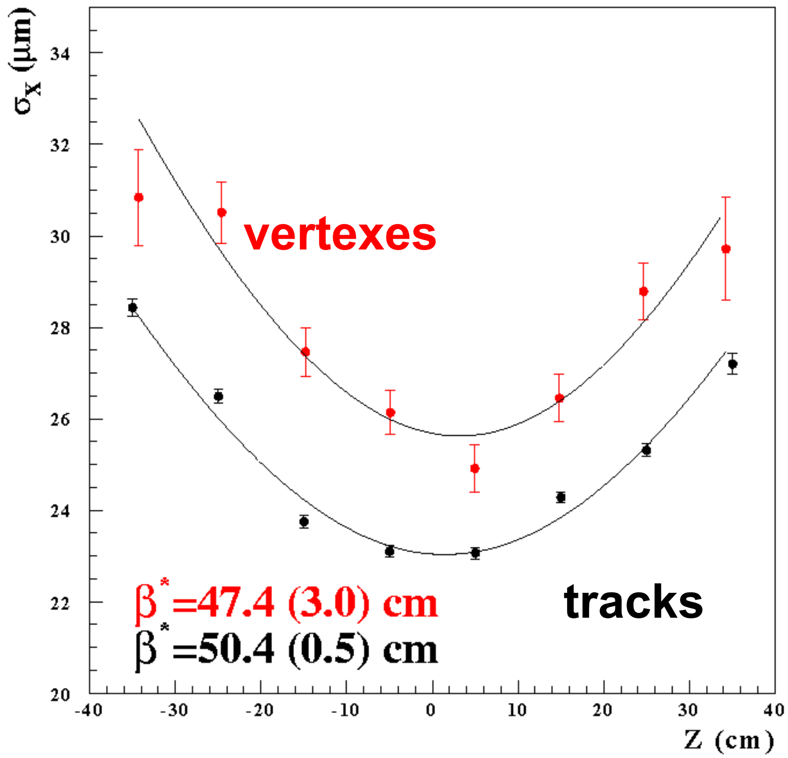
Using reco both method give us a 10% bias. For the vertex method this is solved with the re-vertexing done in dØroot.

β^0 measurement: systematics

Evaluation of the systematics comparing our two measurements.

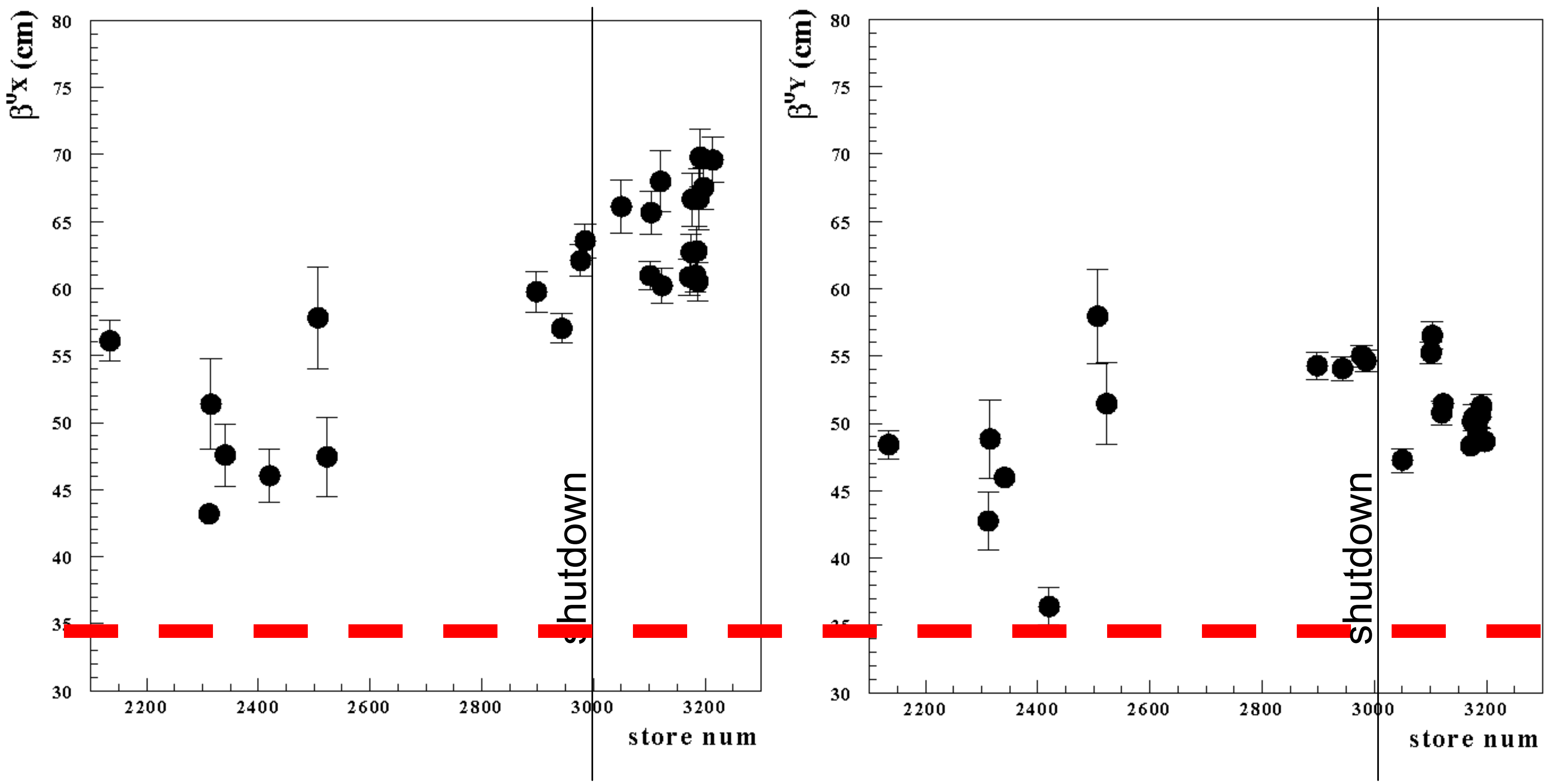
We still have systematic uncertainty in beta*. **The two different measurements still give different result** . This translates into 5% uncertainty in the luminosity ($\propto 1/\beta^*$) calculation using the beam instrumentation measurements. **Work going on to reduce this uncertainty**.

This uncertainty can not explain the difference between 35 and 50 cm.



β^* measurement

Now we are starting to calculate the beam shape in a regular basis, and the information is communicated to the Tevatron department (Vaia Papadimitriou), working in this project with Avdhesh Chandra, student from Tata Institute.



This information is online and Tevatron department has access to it.

DØ vs CDF comparison

Table produced by Vaia using our data and that of CDF.

store	time	βx cm	βx cm	βy cm	βy cm	εx cm rad	εx cm rad	εy cm rad	εy cm rad	L E30	L E30
		CDF	D0	CDF	D0	CDF E-7	D0 E-7	CDF E-7	D0 E-7	CDF Peak avg	D0 Peak avg
2985	3/09 03	32.3 ±1.77	63.5 ±1.29	35.7 ±2.44	54.7 ±0.84	1.28 ±0.05	0.91 ±0.02	1.09 ±0.05	1.07 ±0.01	35.4 21.4	31.6 19.4
3120	31/12 04	36.5 ±2.44	68.0 ±2.27	33.6 ±3.12	50.8 ±0.90	1.29 ±0.06	0.83 ±0.02	0.80 ±0.04	1.26 ±0.02	28.1 15.0	26.5 14.4
3123	2/01 04	42.4 ±2.15	60.2 ±1.33	41.9 ±2.41	51.5 ±0.70	1.43 ±0.05	1.12 ±0.02	1.07 ±0.04	1.54 ±0.02	45.8 20.4	41.9 19.4

DØ vs CDF comparison

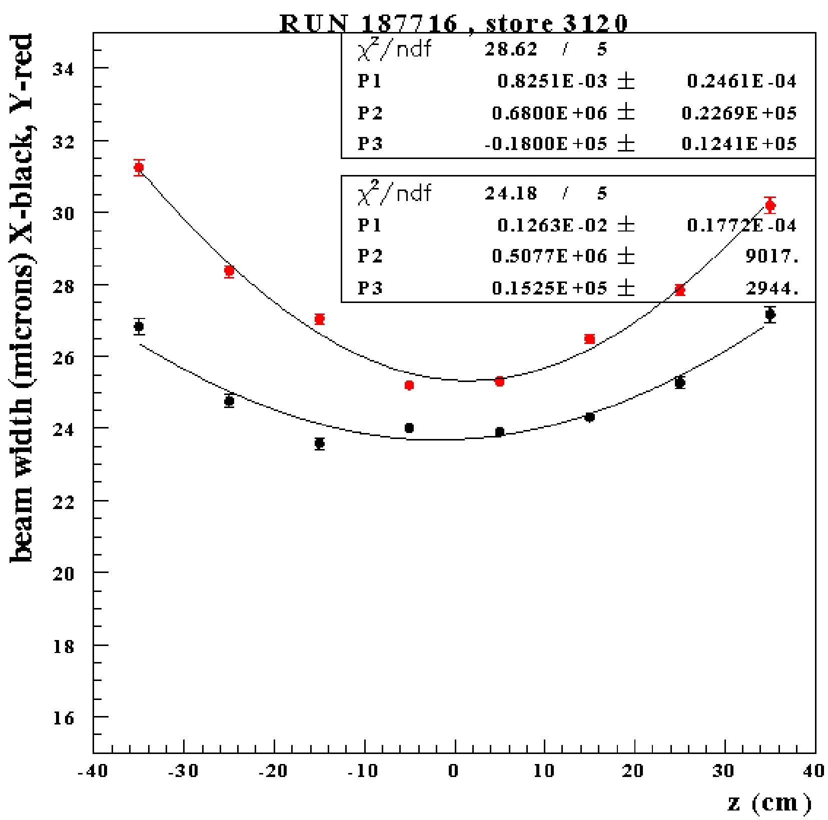
Table produced by Vaia using our data and that of CDF.

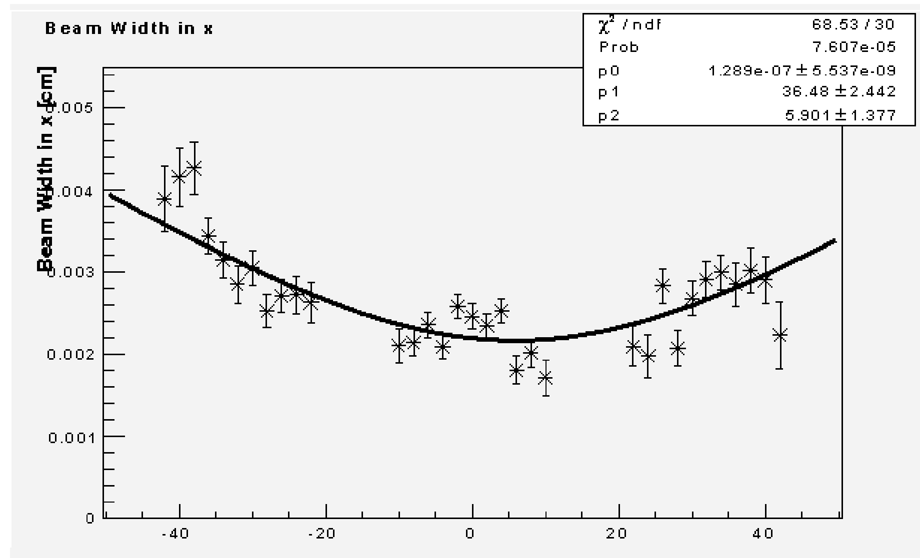
store	$\sigma x \sigma y$	$\sigma x \sigma y$	$1/ \sigma x \sigma y$	$1/ \sigma x \sigma y$	L_{CDF}/L_{D0}	L_{CDF}/L_{D0}	L_{CDF}/L_{D0}
	CDF	D0	CDF	D0	β^*	peak	avg
2985	40.110	58.155	0.0249	0.0172	1.45	1.12	1.10
3120	35.579	60.104	0.0281	0.0166	1.69	1.06	1.04
3123	52.142	73.127	0.0192	0.0137	1.40	1.09	1.05

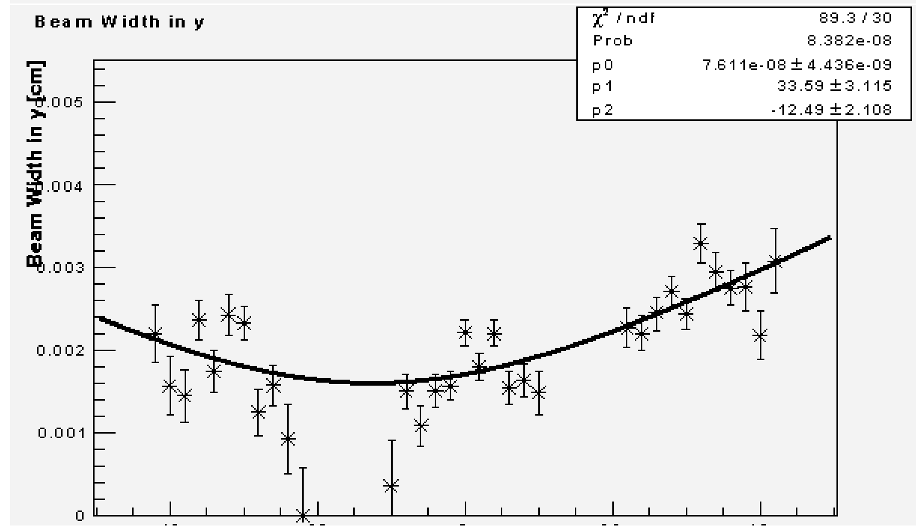
I think we can trust these columns.

Our model for β^* is over simplified, the same is true for the luminosity formula…. I would not pay to much attention to $L_{CDF}/L_{D\text{Ø}}(\beta^*)$~1.5.

DØ vs BØ comparison

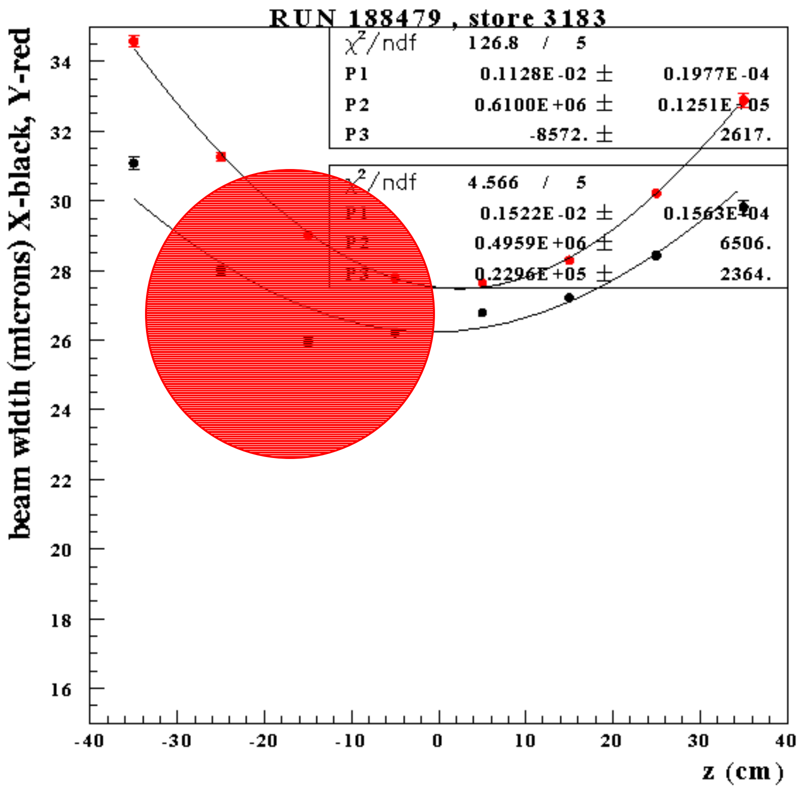


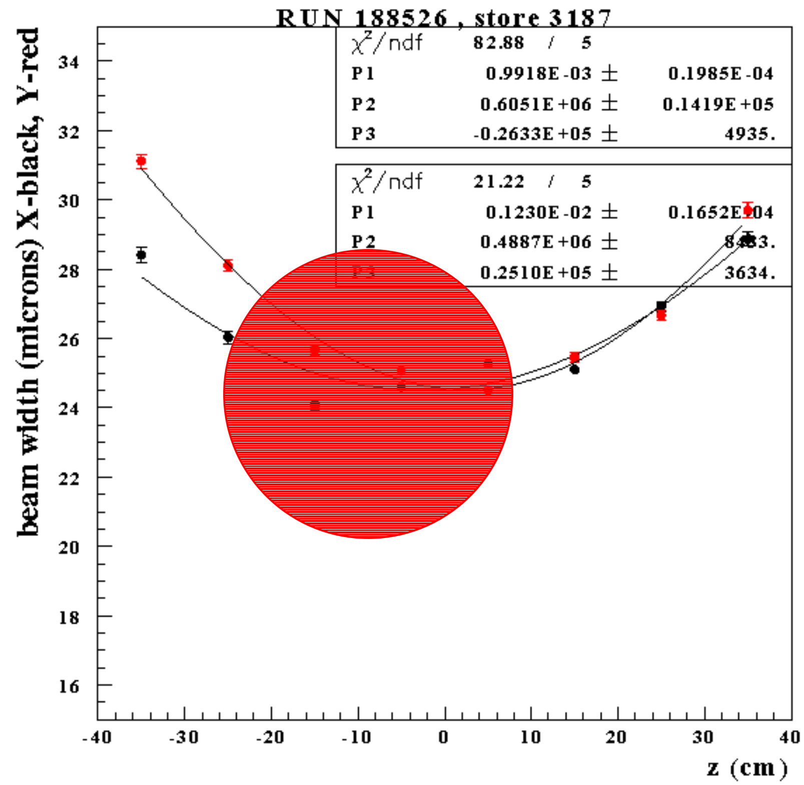




Forget about the fit, look at the shapes….

More stores…

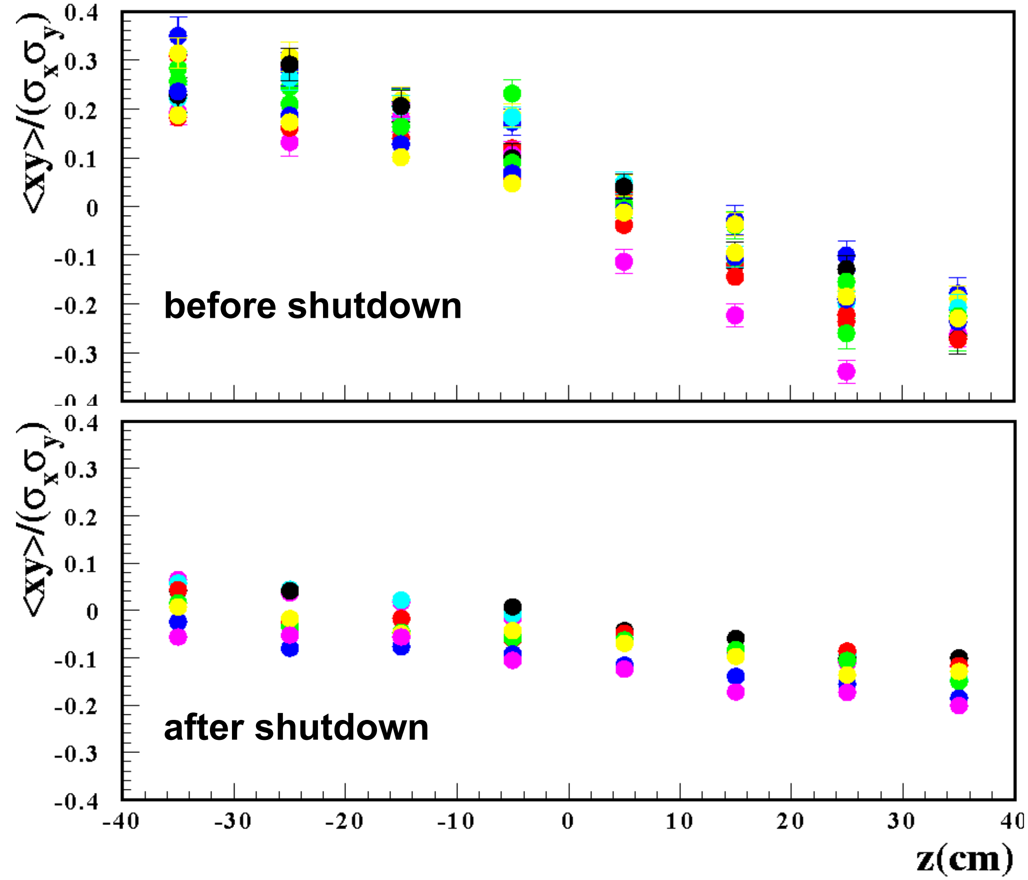




The trend is always there….

X-Y coupling

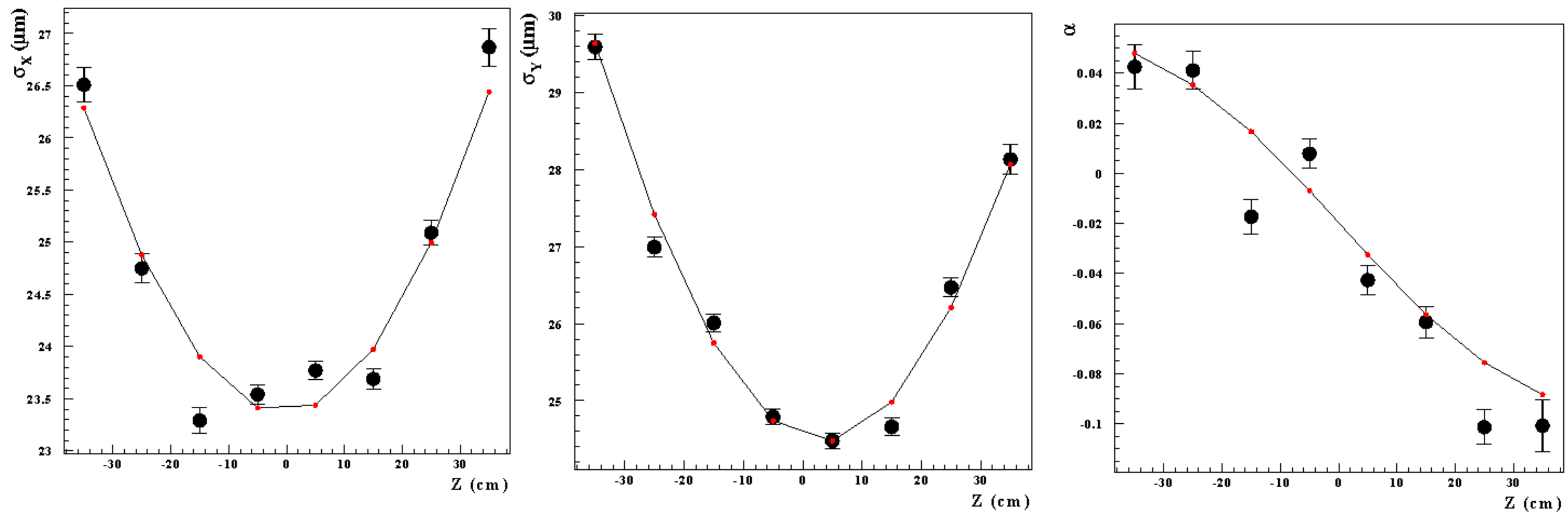
Our model for the β^* measurements is too simple, start taking into account other things. For example, couplings:



After the shutdown the X-Y coupling at DØ has been significantly reduced.

consistent with the expectations from the Tevatron department (Valeri Lebedev)

X-Y coupling (model from V.Lebedev)



This model still does not take into account p-pbar differences. More complex picture (10 beam parameters instead of 3).

Still gives β^*~60 cm for X and β^*~50 cm for Y. Does not solve the problem!

Conclusion

Our results show that the luminous region is more cylindrical and wider at DØ compared to the Tevatron department expextations. The trend is clear, and tested with two independent methods.

Asumming:

- CDF is doing the same measurement (same bias if any).

We can conclude at DØ's IP the beam is larger and mode cylindrical than at BØ's.This is only part of the luminosity calculation…

I am around here

Assuming :

- no X-Y coupling
- No cogging
- Head on collision

We can estimate that DØ has less luminosity delivered than CDF.

Assuming:

- No X-Y coupling (we know it is not true and have proof)
- same β^* for protons and antiprotons (we know it is not true, but have no proof)

We can measure β^* : DØ~50 cm and BØ~35 cm